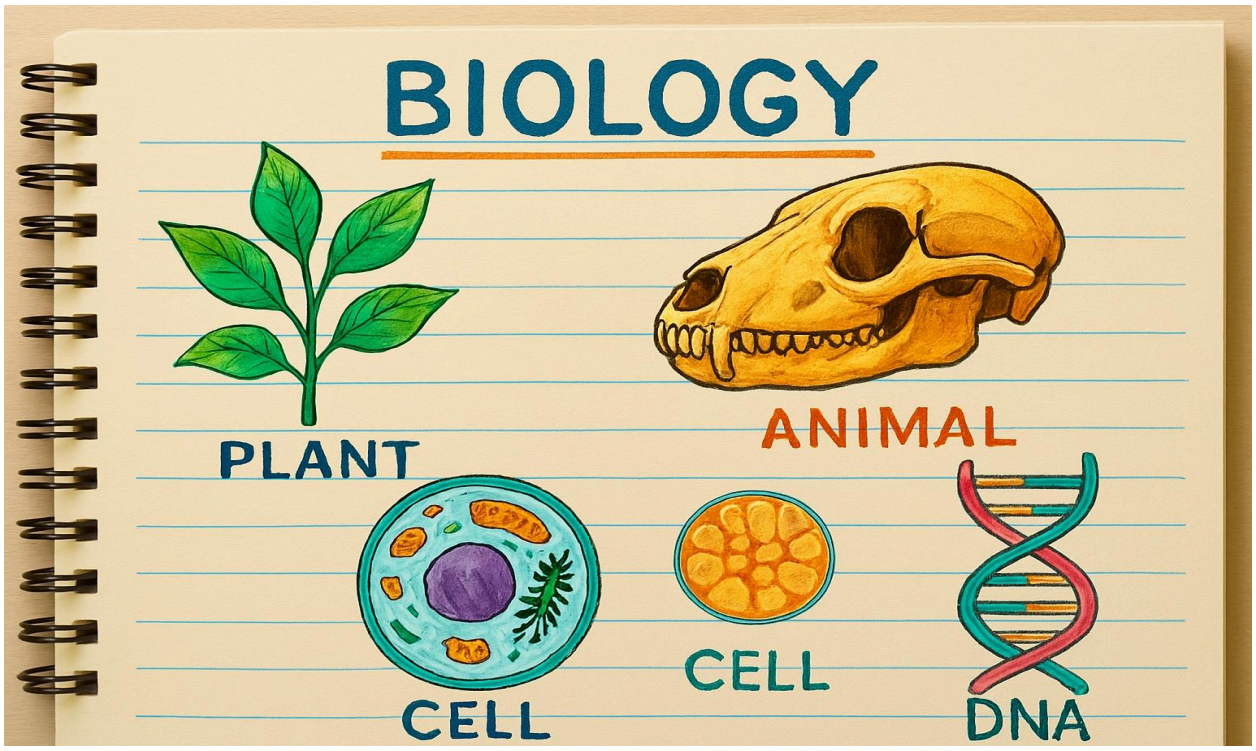


Class: 11th

Subject: Biology

Chapter 5:

ENZYMES

❖ Important MCQs:

1. Enzymes are chemically classified as:

(a) Lipids

(b) Carbohydrates

(c) Proteins ✅

(d) Vitamins

2. Enzymes speed up chemical reactions by:

(a) Increasing activation energy

(b) Decreasing activation energy ✅

(c) Increasing temperature

(d) Consuming substrate

3. Enzymes are also known as:

(a) Hormones

(b) Biocatalysts ✅

(c) Cofactors

(d) Inhibitors

4. During an enzyme-catalysed reaction, the enzyme:

(a) Is permanently changed

(b) Is consumed

(c) Remains unaltered ✅

(d) Becomes substrate

5. Different cells contain different sets of enzymes because:

(a) All cells perform identical functions

(b) Cells have different chemical activities ✅

(c) Enzymes are not specific

(d) Ribosomes destroy enzymes

6. Enzymes are synthesized in the cell by:

(a) Mitochondria

(b) Lysosomes

(c) Ribosomes ✅

(d) Golgi apparatus

7. The small cleft on the surface of an enzyme where substrate binds is called:

(a) Binding pocket

(b) Active site ✅

(c) Catalytic loop

(d) Peptide bond

8. The active site of an enzyme consists of:

(a) Many lipid molecules

(b) All amino acids of enzyme

(c) A few specific amino acids ✅

(d) DNA segments

9. The region of active site where substrate attaches by weak forces is called:

(a) Catalytic site

(b) Binding site ✅

(c) Ribosomal site

(d) Membrane site

10. Substrate molecules bind to enzyme active site through:

(a) Strong covalent bonds

(b) Ionic explosions

(c) Hydrogen bonds and weak forces ✅

(d) Peptide bonds

11. Additional non-protein components required by some enzymes are called:

(a) Substrates

(b) Cofactors ✅

(c) Products

(d) Inhibitors

12. Which of the following is NOT a type of cofactor?

(a) Metal ions

(b) Prosthetic groups

(c) Coenzymes

(d) Ribosomes ✅

13. A cofactor that forms a covalent bond with enzyme is called:

(a) Coenzyme

(b) Metal ion

(c) Prosthetic group ✅

(d) Activator

14. When a non-protein organic molecule is loosely attached to an enzyme, it is called:

(a) Prosthetic group

(b) Metal ion

(c) Coenzyme ✅

(d) Substrate

15. The most important hydrogen acceptor coenzyme in the cell is:

(a) FAD

(b) ATP

(c) NAD^+ ✅

(d) Hematin

16. The speed of a chemical reaction mainly depends on:

(a) Substrate size

(b) Activation energy ✅

(c) Product colour

(d) Enzyme weight

17. Activation energy is the energy required to:

(a) Form products directly

(b) Destabilize existing chemical bonds ✅

(c) Increase temperature

(d) Destroy enzyme

18. Enzymes increase reaction rate by:

(a) Increasing activation energy

(b) Lowering activation energy ✅

(c) Changing end products

(d) Consuming substrate

19. The presence of enzyme does NOT change the:

(a) Rate of reaction

(b) Activation energy

(c) Nature of end products ✅

(d) Formation of ES complex

20. When substrate binds to enzyme, it forms:

(a) Product complex

(b) Enzyme-product complex

(c) Enzyme-substrate complex ✅

(d) Catalytic bond

21. In enzyme action, catalytic site:

(a) Binds substrate only

(b) Produces energy

(c) Stresses specific bonds of substrate ✅

(d) Destroys products

22. After completion of reaction, enzyme:

(a) Is permanently altered

(b) Is consumed

(c) Remains unaltered ✅

(d) Changes into product

23. In metabolic pathways, the product of one enzyme becomes:

(a) Waste material

(b) Inhibitor

(c) Substrate for next enzyme ✅

(d) Cofactor

24. The final product of a metabolic pathway often inhibits:

(a) Last enzyme

(b) Middle enzyme

(c) First enzyme (feedback inhibition) ✅

(d) All enzymes equally

25. Lock-and-key model was proposed by:

(a) Daniel Koshland

(b) Louis Pasteur

(c) Emil Fischer ✅

(d) Watson

26. According to lock-and-key model, active site is:

(a) Flexible

(b) Rigid ✅

(c) Temporary

(d) Destroyed after reaction

27. Induced fit model was proposed in 1958 by:

(a) Emil Fischer

(b) Robert Hooke

(c) Daniel Koshland ✅

(d) Mendel

28. According to induced fit model, active site:

(a) Is permanently rigid

(b) Changes shape when substrate binds ✅

(c) Is absent

(d) Is destroyed after reaction

29. In induced fit model, substrate binding causes:

(a) No structural change

(b) Enzyme destruction

(c) Structural modification in enzyme ✅

(d) Product inhibition

30. Which model explains flexibility of active site?

(a) Lock-and-key model

(b) Induced fit model ✅

(c) Feedback model

(d) Cofactor model

31. Enzyme activity is mainly affected by changes in its:

(a) Colour

(b) Three-dimensional shape ✅

(c) Size

(d) Weight

32. The optimum temperature for most human enzymes is:

(a) 25°C

(b) 30°C

(c) 37°C ✅

(d) 45°C

33. At temperatures below optimum, enzyme activity decreases because:

(a) Enzyme is destroyed

(b) Bonds become less flexible ✅

(c) Substrate is removed

(d) Products increase

34. Increase in temperature up to a limit increases reaction rate due to:

(a) Decrease in activation energy

(b) Increased kinetic energy and collisions ✅

(c) Enzyme consumption

(d) Product inhibition

35. Extremely high temperature causes:

(a) Activation

(b) Stabilization

(c) Denaturation ✅

(d) Inhibition by substrate

36. Denaturation results in:

(a) Increase in enzyme activity

(b) Loss of globular structure ✅

(c) Formation of new enzyme

(d) Increased pH

37. Each enzyme works best at a specific pH called:

(a) Neutral pH

(b) Critical pH

(c) Optimum pH ✅

(d) Standard pH

38. Pepsin shows maximum activity in:

(a) Alkaline medium

(b) Neutral medium

(c) Acidic medium ✅

(d) Basic salt solution

39. Trypsin works best in:

(a) Acidic medium

(b) Alkaline medium ✅

(c) Neutral water

(d) High temperature

40. Extreme change in pH may cause:

(a) Activation

(b) Increased flexibility

(c) Enzyme denaturation ✅

(d) Faster product formation

41. Bonds between oppositely charged amino acids are sensitive to:

(a) Temperature only

(b) Light

(c) Hydrogen ion concentration (pH) ✅

(d) Oxygen

42. If substrate concentration is unlimited, reaction rate depends directly on:

(a) pH

(b) Temperature

(c) Enzyme concentration ✅

(d) Product colour

43. Increasing enzyme concentration increases reaction rate because:

(a) Fewer active sites are available

(b) More active sites are available ✅

(c) Substrate decreases

(d) Products are removed

44. If enzyme concentration increases but substrate remains constant, the reaction rate will:

(a) Increase continuously

(b) Decrease

(c) Remain constant after a point ✅

(d) Stop immediately

45. When substrate concentration increases and active sites are free, reaction rate:

(a) Decreases

(b) Increases ✅

(c) Stops

(d) Remains unchanged

46. When all active sites are occupied, the reaction rate:

(a) Increases rapidly

(b) Decreases sharply

(c) Remains constant ✅

(d) Becomes zero

47. The point at which further increase in substrate does not increase reaction rate is due to:

(a) Enzyme saturation ✅

(b) Low temperature

(c) High pH

(d) Denaturation

48. Hydrophobic interactions in enzymes are easily disrupted by changes in:

(a) Pressure

(b) Temperature ✅

(c) Colour

(d) Sound

49. Small number of enzyme molecules can catalyse:

(a) Only small amount of substrate

(b) Large amount of substrate ✅

(c) No reaction

(d) Only one reaction once

50. Reaction rate decreases rapidly at very high temperature because:

(a) Substrate increases

(b) Active site becomes larger

(c) Enzyme structure is destroyed ✅

(d) pH becomes neutral

51. A chemical that blocks enzyme activity is called:

(a) Cofactor

(b) Substrate

(c) Inhibitor ✅

(d) Product

52. Enzyme inhibition occurs when an inhibitor:

(a) Is converted into product

(b) Attaches to enzyme and blocks its activity ✅

(c) Increases activation energy

(d) Changes substrate

53. Final products of complex enzymatic reactions often act as:

(a) Activators

(b) Cofactors

(c) Inhibitors of first enzyme ✅

(d) Substrates

54. A competitive inhibitor resembles the:

(a) Product

(b) Cofactor

(c) Substrate ✅

(d) Enzyme

55. Competitive inhibitors block enzyme activity by:

(a) Binding to a site other than active site

(b) Destroying enzyme

(c) Competing for active site ✅

(d) Increasing pH

56. Non-competitive inhibitors bind to:

(a) Active site only

(b) Substrate

(c) Another site on enzyme ✅

(d) Product

57. Binding of a non-competitive inhibitor causes:

(a) Formation of more products

(b) No structural change

(c) Change in enzyme shape ✅

(d) Increased substrate binding

58. Irreversible inhibitors usually form:

(a) Hydrogen bonds

(b) Weak ionic bonds

(c) Covalent bonds ✅

(d) Temporary bonds

59. Reversible inhibitors can be removed by:

(a) Heating enzyme

(b) Increasing substrate concentration ✅

(c) Breaking peptide bonds

(d) Adding more inhibitor

60. Penicillin is an example of:

(a) Competitive inhibitor

(b) Reversible inhibitor

(c) Irreversible inhibitor ✅

(d) Cofactor

61. Enzyme inhibition helps in regulating:

(a) Cell colour

(b) Metabolic pathways ✅

(c) DNA structure

(d) Temperature

62. Many antibiotics work by:

(a) Increasing enzyme activity

(b) Destroying substrates

(c) Inhibiting bacterial enzymes ✅

(d) Increasing pH

63. Some drugs used in cancer therapy act by:

(a) Activating enzymes

(b) Inhibiting enzymes involved in cell division ✅

(c) Increasing ATP

(d) Decreasing temperature

64. Enzyme inhibitors used to prevent blood clotting are called:

(a) Antibiotics

(b) Anticoagulants ✅

(c) Hormones

(d) Cofactors

65. Some toxins and poisons are harmful because they:

(a) Increase enzyme activity

(b) Inhibit important enzymes ✅

(c) Form substrates

(d) Act as coenzymes

66. Feedback inhibition helps to:

(a) Increase final product

(b) Shut down metabolic pathway when product is sufficient ✅

(c) Destroy enzymes

(d) Increase activation energy

67. In feedback inhibition, the final product acts on:

(a) Last enzyme

(b) Middle enzyme

(c) First enzyme of pathway ✅

(d) All enzymes equally

68. When excess ATP is present in a cell, it acts as:

(a) Competitive inhibitor

(b) Substrate

(c) Non-competitive inhibitor ✅

(d) Cofactor

69. Enzymes are classified mainly on the basis of:

(a) Their colour

(b) Their size

(c) Reactions they catalyse ✅

(d) Temperature

70. Oxidoreductases catalyse:

(a) Hydrolysis

(b) Oxidation-reduction reactions ✅

(c) Bond formation using ATP

(d) Isomer formation

71. Transferases catalyse the transfer of:

(a) Electrons only

(b) Functional groups ✅

(c) Water

(d) Oxygen gas

72. Hydrolases catalyse reactions by:

(a) Removing CO_2

(b) Adding water to break bonds ✅

(c) Rearranging atoms

(d) Using ATP

73. Lyases catalyse:

(a) Hydrolysis reactions

(b) Non-hydrolytic removal or addition of groups ✅

(c) Oxidation only

(d) Isomer formation only

74. Isomerases catalyse:

(a) Bond breaking by water

(b) Joining of molecules

(c) Intra-molecular rearrangement ✅

(d) Oxidation reactions

75. Ligases join molecules by using energy from:

(a) NADH

(b) ATP ✅

(c) Oxygen

(d) CO_2

76. Proteases are enzymes that break down:

(a) Lipids

(b) Carbohydrates

(c) Proteins ✅

(d) Nucleic acids

77. Lipases catalyse the breakdown of:

(a) Proteins

(b) Lipids ✅

(c) Starch

(d) DNA

78. Amylase converts starch into:

(a) Glucose only

(b) Maltose ✅

(c) Fructose

(d) Galactose

79. Nucleases act upon:

(a) Lipids

(b) Proteins

(c) Nucleic acids ✅

(d) Carbohydrates

80. Lactase breaks lactose into:

(a) Glucose and fructose

(b) Glucose and galactose ✅

(c) Maltose and glucose

(d) Fatty acids and glycerol

📘 EXERCISE

SECTION 1: MULTIPLE CHOICE QUESTIONS

1. What roles does nicotinamide adenine dinucleotide play in oxidative pathways?

(a) Enzyme

(b) Coenzyme ✅

(c) Prosthetic group

(d) Inhibitor

2. The enzymes that catalyse the reactions in which two molecules are joined together by synthesis of new bonds, using energy from ATP, are placed in group;

(a) Hydrolase

(b) Ligase ✅

(c) Lyase

(d) Transferase

3. Which of the following is an example of hydrolases?

(a) Lipase ✅

(b) Glycogen phosphorylase

(c) Pyruvate decarboxylase

(d) Cytochrome oxidase

4. Which of the following statements about enzymes is correct?

(a) They increase the activation energy of a reaction.

(b) They are consumed during the reaction.

(c) They are specific in terms of the reactions they catalyse. ✅

(d) They always work optimally at high temperatures.

5. Enzyme B requires Zn^{+} to catalyse the conversion of substrate X. The zinc is best identified as a(n):

(a) Coenzyme

(b) Activator ✅

(c) Substrate

(d) Product

6. If an enzyme solution is saturated with substrate, the most effective way to obtain an even faster yield of products would be

(a) Add more of the enzymes ✅

(b) Add more substrate

(c) Add an allosteric inhibitor

(d) Add a non-competitive inhibitor

7. How does a non-competitive inhibitor decrease the rate of an enzyme-catalysed reaction?

(a) By binding the active site of the enzyme

(b) By changing the shape of the enzyme ✅

(c) By changing the free energy change of the reaction

(d) By acting as a coenzyme for the reaction

8. Which enzyme class is responsible for catalysing the addition of water to a substrate molecule?

(a) Ligase

(b) Lyase

(c) Hydrolase ✅

(d) Isomerase

SECTION 2: SHORT QUESTIONS – ANSWERS

1. Define enzyme and co-factor

Answer:

Enzyme: An enzyme is a protein that speeds up chemical reactions in living organisms without being consumed or permanently changed.

Example: Amylase is an enzyme that breaks down starch into sugar.

Co-factor: A co-factor is a non-protein substance that helps an enzyme perform its function. Co-factors can be metal ions or small organic molecules.

Example: Magnesium ion (Mg^{2+}) helps some enzymes work; NAD^+ acts as a co-enzyme in redox reactions.

2. Differentiate between co-enzyme and prosthetic group

Answer:

Co-enzyme: A co-enzyme is a loosely attached organic molecule that helps transfer chemical groups between enzymes.

Example: NAD^+ and FAD act as co-enzymes in energy metabolism.

Prosthetic group: A prosthetic group is a molecule (organic or inorganic) that is tightly bound to an enzyme and is essential for its activity.

Example: Heme in cytochrome enzymes, Biotin in carboxylase.

3. What do you mean by hydrolases? Give two examples

Answer:

Hydrolases: Hydrolases are enzymes that break chemical bonds in molecules by adding water (hydrolysis).

Examples: Amylase breaks starch into maltose (sugar), Lipase breaks lipids into fatty acids and glycerol.

4. What is meant by activation energy?

Answer:

Activation energy: Activation energy is the minimum energy required to start a chemical reaction.

Example: Breaking hydrogen bonds in protein molecules during digestion requires activation energy.

5. Define feedback inhibition

Answer:

Feedback inhibition: Feedback inhibition is a process in which the end product of a metabolic pathway inhibits an enzyme that acts earlier in the same pathway to prevent overproduction.

Example: In the Threonine to Isoleucine pathway, if Isoleucine accumulates, it inhibits the first enzyme in the pathway to stop its own excess production.

6. Give examples of competitive and non-competitive inhibitors

Answer:

Competitive inhibitor: A competitive inhibitor binds to the active site of an enzyme, competing with the substrate.

Example: Sulfonamides compete with PABA in bacterial enzymes, stopping bacterial growth.

Non-competitive inhibitor: A non-competitive inhibitor binds to a site other than the active site, changing the enzyme's shape and preventing it from working.

Example: Cyanide binds to cytochrome oxidase, stopping cellular respiration.

SECTION 3: LONG QUESTIONS

🌟 **Q1: Describe the structure of an enzyme, explaining the role and component parts of the active site of an enzyme.**

❖ **Answer:**

1. Structure of an Enzyme:

Enzymes are biological catalysts, mostly made of proteins, that accelerate chemical reactions without being consumed. Some enzymes may also have a non-protein part called a co-factor that is essential for activity. The overall structure of an enzyme determines its specificity, i.e., which substrate it can bind and act upon.

Enzymes have two main structural regions:

- **A. Apoenzyme:** The protein portion of the enzyme. This part is inactive on its own.
- **B. Holoenzyme:** The active form of the enzyme, which includes the apoenzyme plus its co-factor (if any).

2. Active Site of an Enzyme:

The active site is a special region on the enzyme where the substrate binds and the chemical reaction occurs. The structure of the active site is complementary to the shape of the substrate, which explains why enzymes are highly specific.

The active site consists of:

1. Binding Site:

- This part holds the substrate in the correct position by weak forces such as hydrogen bonds, van der Waals forces, and ionic interactions.
- **Example:** In the enzyme sucrase, the binding site holds sucrose in place for hydrolysis.

2. Catalytic Site:

- This part contains amino acid residues that participate directly in the chemical reaction, helping break or form bonds in the substrate.
- It is responsible for lowering the activation energy required for the reaction.

3. Mechanism of Substrate Binding:

Enzymes can bind substrates through two models:

- **Lock and Key Model:** The active site is a perfect fit for the substrate, like a key fitting into a lock.
- **Induced Fit Model:** The enzyme slightly changes shape to fit the substrate perfectly, allowing better interaction and reaction efficiency.

4. Role of the Active Site:

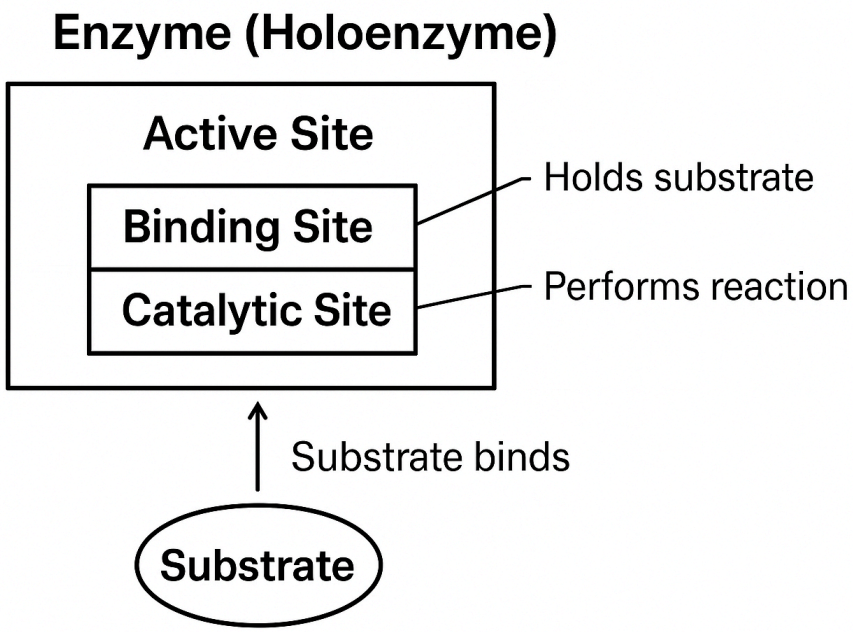
- Provides a specific environment for the reaction to occur.
- Stabilizes the transition state of the substrate.

- Lowers the activation energy, making the reaction faster.
- Ensures specificity by allowing only particular substrates to bind.

5. Components and Important Features:

- **Amino Acid Residues:** Provide chemical groups that help in catalysis.
- **Cleft or Pocket:** The 3D shape of the site where the substrate fits.
- **Co-factors or Co-enzymes (if required):** Help the enzyme in the reaction (e.g., NAD^+, Mg^{2+}).

6. Diagram of Enzyme Structure and Active Site:



Example:

Amylase enzyme: The active site binds starch molecules at the binding site. The catalytic residues break starch into maltose efficiently.

✦ **Summary:**

- Enzymes are proteins that act as biological catalysts.
- The active site is the specific region where the substrate binds and the reaction occurs.
- The active site consists of a binding site (for holding the substrate) and a catalytic site (for performing the chemical reaction).
- Enzymes work by lowering activation energy and stabilizing the transition state.
- The structure of the active site explains enzyme specificity.
- Co-factors or co-enzymes, if required, assist the enzyme in catalysis.

🌟 **Q 2: Differentiate among the three types of co-factors, by giving examples.**

❖ **Answer:**

Co-factors are non-protein components required by some enzymes to perform their biological functions. The protein part of an enzyme alone (called the apoenzyme) is often inactive. When the co-factor binds to it, the complete active enzyme is formed, known as the holoenzyme.

✦ **Co-factors are classified into three main types:**

1. Metal Ion Co-factors

These are inorganic ions that help enzymes carry out their catalytic activity. They may assist in stabilizing the enzyme structure or participate directly in the chemical reaction.

Metal ions are usually loosely attached to the enzyme.

Examples:

- Mg^{2+} is required by many enzymes involved in DNA replication and ATP-related reactions.
- Zn^{2+} is required for the enzyme carbonic anhydrase.
- Fe^{2+} / Fe^{3+} is involved in redox reactions in certain enzymes.

Function:

Metal ions help in stabilizing negative charges, activating substrates, or maintaining proper enzyme shape.

2. Co-enzymes

Co-enzymes are organic, non-protein molecules that bind loosely to the enzyme. They usually act as carriers of chemical groups or electrons during the reaction.

They are often derived from vitamins.

Examples:

- NAD^+ (Nicotinamide adenine dinucleotide) carries electrons in respiration.
- FAD (Flavin adenine dinucleotide) participates in oxidation-reduction reactions.

- Coenzyme A (CoA) carries acetyl groups in metabolism.

Function:

Co-enzymes temporarily bind to the enzyme, assist in the reaction, and are released after the reaction is completed.

3. Prosthetic Groups

Prosthetic groups are organic or inorganic molecules that are tightly and permanently attached to the enzyme.

Unlike co-enzymes, they do not detach after the reaction.

Examples:

- Heme group in cytochrome enzymes and catalase.
- Biotin in carboxylase enzymes.

Function:

They play a direct role in catalysis and remain firmly bound to the enzyme throughout its activity.

Key Differences in Explanation Form

- Metal ion co-factors are inorganic ions that assist enzyme activity, usually by stabilizing structure or participating in reactions.
- Co-enzymes are organic molecules that bind loosely and act as carriers of electrons or chemical groups.

- Prosthetic groups are tightly bound molecules that remain permanently attached to the enzyme and are essential for its function.

✦ **Summary:**

Co-factors are non-protein substances required for enzyme activity.

There are three types:

1. Metal ions (e.g., Mg^{2+}, Zn^{2+})
2. Co-enzymes (e.g., NAD^{+}, FAD)
3. Prosthetic groups (e.g., Heme, Biotin)

- Metal ions are inorganic.
- Co-enzymes are organic and loosely attached.
- Prosthetic groups are tightly and permanently attached.

🌟 **Q3: Explain the mechanism of enzyme action through Induced Fit Model, comparing it with Lock and Key Model.**

❖ **Answer:**

Enzymes are biological catalysts that speed up chemical reactions by lowering activation energy. To understand how enzymes work, scientists proposed two models: the Lock and Key Model and the Induced Fit Model.

1. Lock and Key Model

The Lock and Key Model was proposed by Emil Fischer in 1894.

According to this model, the active site of the enzyme is rigid and has a fixed shape. It is exactly complementary to the shape of the substrate. The substrate fits into the active site just like a key fits into a lock.

Mechanism:

- The substrate approaches the enzyme.
- The substrate fits perfectly into the active site.
- An enzyme-substrate complex is formed.
- The reaction occurs.
- Products are released, and the enzyme remains unchanged.

Limitation:

This model does not explain how enzymes can change shape during reactions or how they stabilize the transition state.

2. Induced Fit Model

The Induced Fit Model was proposed by Daniel Koshland in 1958.

According to this model, the active site of the enzyme is not rigid. Instead, it is flexible. When the substrate approaches the enzyme, it induces a change in the shape of the active site so that the enzyme fits more closely around the substrate.

Mechanism of Induced Fit Model:

1. The substrate approaches the enzyme.
2. The active site is roughly complementary but not an exact fit.
3. When the substrate binds, the enzyme changes its shape.

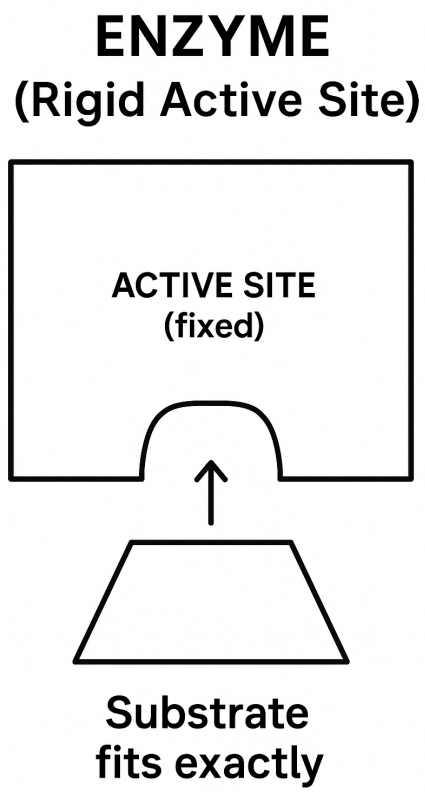
4. The active site molds itself around the substrate.
5. The enzyme stabilizes the transition state and lowers activation energy.
6. The reaction takes place.
7. The product is released, and the enzyme returns to its original shape.

Example:

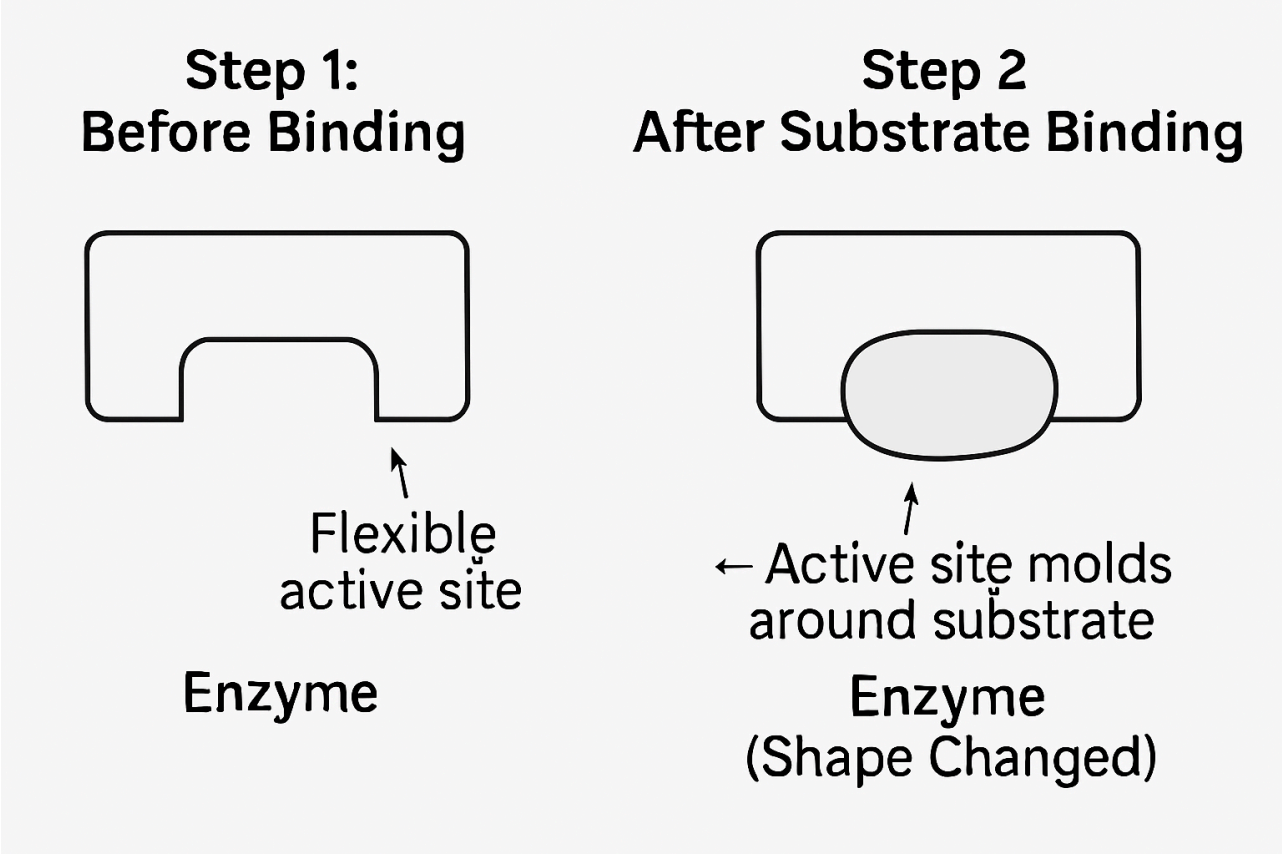
Hexokinase enzyme changes its shape when glucose binds to it during glycolysis.

Diagram of Both Models

Lock and Key Model



Induced Fit Model



Comparison Between Lock and Key and Induced Fit Model

- Lock and Key Model states that the active site is rigid and already perfectly shaped for the substrate.
- Induced Fit Model states that the active site is flexible and changes shape when the substrate binds.
- Lock and Key Model explains specificity but does not explain enzyme flexibility.
- Induced Fit Model explains both specificity and the stabilization of the transition state.
- The Induced Fit Model is more widely accepted because it explains experimental observations more accurately.

✦ **Summary:**

- **Lock and Key Model:** Active site is rigid; substrate fits exactly.
- **Induced Fit Model:** Active site is flexible; substrate binding induces shape change.
- Induced Fit Model better explains enzyme flexibility and transition state stabilization.
- Hexokinase is a common example of induced fit behavior.

🌟 **Q4: Define activation energy and explain through graph how an enzyme speeds up a reaction by lowering activation energy.**

❖ **Answer:**

Definition of Activation Energy

Activation energy is the minimum amount of energy required to start a chemical reaction.

Before reactant molecules can be converted into products, they must reach a high-energy, unstable state called the transition state. The energy required to reach this transition state is known as activation energy.

Without sufficient activation energy, the reaction cannot proceed.

Role of Enzymes in Lowering Activation Energy

Enzymes speed up chemical reactions by lowering the activation energy, not by increasing the energy of reactants or changing the final products.

They lower activation energy by:

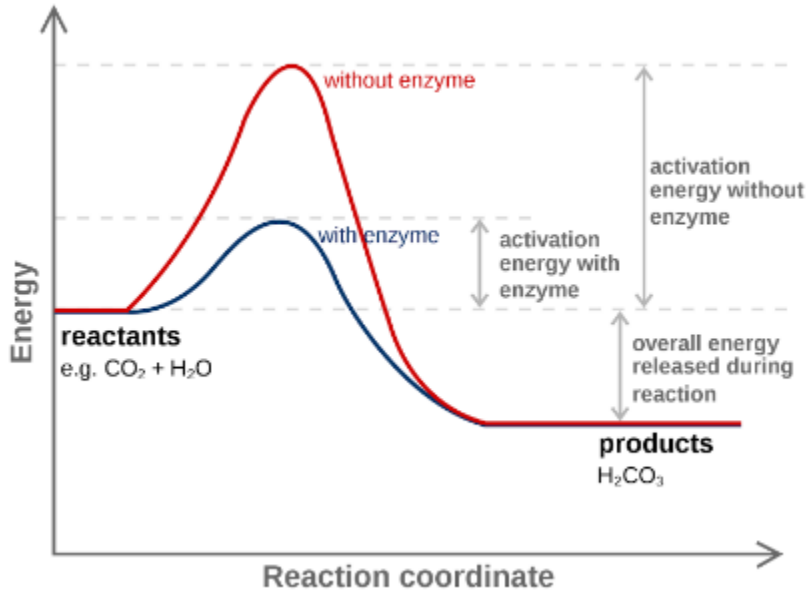
1. Bringing substrates closer together in the correct orientation.
2. Stabilizing the transition state.
3. Reducing bond strain in the substrate.
4. Providing an alternative reaction pathway with lower energy.

Because the activation energy is reduced, more molecules can reach the transition state quickly, and the reaction rate increases.

Explanation Through Graph

The effect of enzyme action can be explained with an energy profile graph.

Graph Showing Activation Energy



Explanation of Graph

- The vertical axis represents Energy.
- The horizontal axis represents Progress of Reaction.
- The higher peak shows activation energy without enzyme.
- The lower peak shows activation energy with enzyme.
- The starting point (reactants) and ending point (products) remain the same in both cases.
- The enzyme only lowers the height of the peak (activation energy).

Important Point

Enzymes do not change:

- The final products
- The overall energy released or absorbed
- The equilibrium of the reaction

They only make the reaction occur faster by lowering activation energy.

Example

During the breakdown of hydrogen peroxide:

- Hydrogen peroxide ⟶ Water + Oxygen
- Without enzyme, this reaction is slow.
- The enzyme catalase lowers the activation energy and speeds up the reaction rapidly.

✦ **Summary:**

- Activation energy is the minimum energy required to start a reaction.
- It is needed to reach the transition state.
- Enzymes lower activation energy by stabilizing the transition state and providing an alternative pathway.
- Lower activation energy results in a faster reaction.
- The enzyme does not change reactants, products, or equilibrium.

🌟 **Q 5: Describe the effect of temperature on the rate of enzyme action.**

❖ **Answer:**

Temperature has a significant effect on the rate of enzyme-controlled reactions because enzymes are proteins and their structure is sensitive to heat.

1. Effect of Low Temperature

At low temperatures:

- Molecules move slowly.
- There are fewer collisions between enzyme and substrate.
- The rate of reaction is slow.

However, the enzyme is not damaged at low temperature. If the temperature increases later, the enzyme regains its normal activity.

2. Effect of Increasing Temperature

As temperature increases:

- Kinetic energy of molecules increases.
- Enzyme and substrate collide more frequently.
- More enzyme-substrate complexes are formed.
- The reaction rate increases.

The reaction rate increases steadily up to a certain temperature called the optimum temperature.

For most human enzymes, the optimum temperature is around 37°C.

3. Optimum Temperature

The optimum temperature is the temperature at which the enzyme works at its maximum rate.

At this temperature:

- The active site has the correct shape.
- Collisions between enzyme and substrate are most effective.
- Maximum enzyme-substrate complexes are formed.

4. Effect of High Temperature

When temperature rises above the optimum:

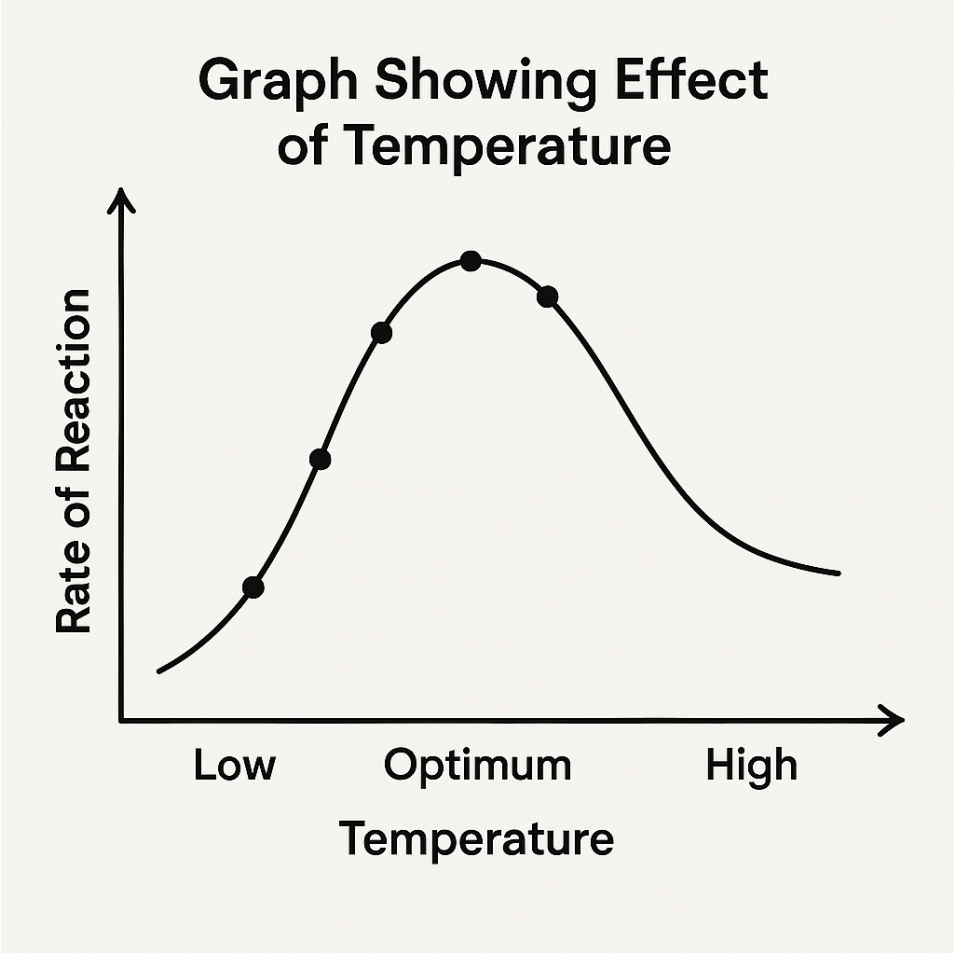
- The enzyme's protein structure begins to break.
- Hydrogen bonds and weak interactions are disrupted.
- The active site loses its specific shape.
- The enzyme becomes denatured.

Denaturation means permanent loss of structure and function.

As a result:

- The reaction rate decreases sharply.
- At very high temperatures, enzyme activity stops completely.

Graph Showing Effect of Temperature



Explanation of Graph

- The rate increases gradually with temperature.
- It reaches a maximum at the optimum temperature.
- After optimum, the rate decreases sharply due to denaturation.

Example

The enzyme catalase works efficiently at 37°C in human cells.

If heated to very high temperature (e.g., 60°C or above), it becomes denatured and loses activity.

Summary:

Temperature increases enzyme activity up to an optimum point by increasing molecular movement and collisions. Beyond the optimum temperature, enzymes lose their structure and become denatured, causing a rapid decrease in reaction rate.

🌟 **Q6: Compare the optimum temperatures of enzymes of human and thermophilic bacteria.**

❖ **Answer:**

The optimum temperature is the temperature at which an enzyme shows its maximum activity. Different organisms have enzymes adapted to their environmental conditions. Therefore, enzymes of humans and thermophilic bacteria have different optimum temperatures.

1. Optimum Temperature of Human Enzymes

Humans are warm-blooded organisms and maintain a constant body temperature of about 37°C.

- Most human enzymes work best at 37°C.
- At this temperature, enzyme structure is stable.

- Enzyme-substrate collisions occur efficiently.
- Maximum enzyme activity is observed.

If temperature rises significantly above 37°C:

- The enzyme begins to denature.
- The active site loses its specific shape.
- The reaction rate decreases rapidly.

For example, human enzyme pepsin works best near body temperature.

2. Optimum Temperature of Thermophilic Bacteria Enzymes

Thermophilic bacteria live in extremely hot environments such as hot springs and hydrothermal vents.

- Their enzymes have an optimum temperature between 60°C to 80°C or even higher.
- These enzymes are heat-stable.
- Their protein structure contains stronger bonds that prevent denaturation at high temperatures.

For example, Taq polymerase, obtained from the bacterium Thermus aquaticus, works best at about 72°C.

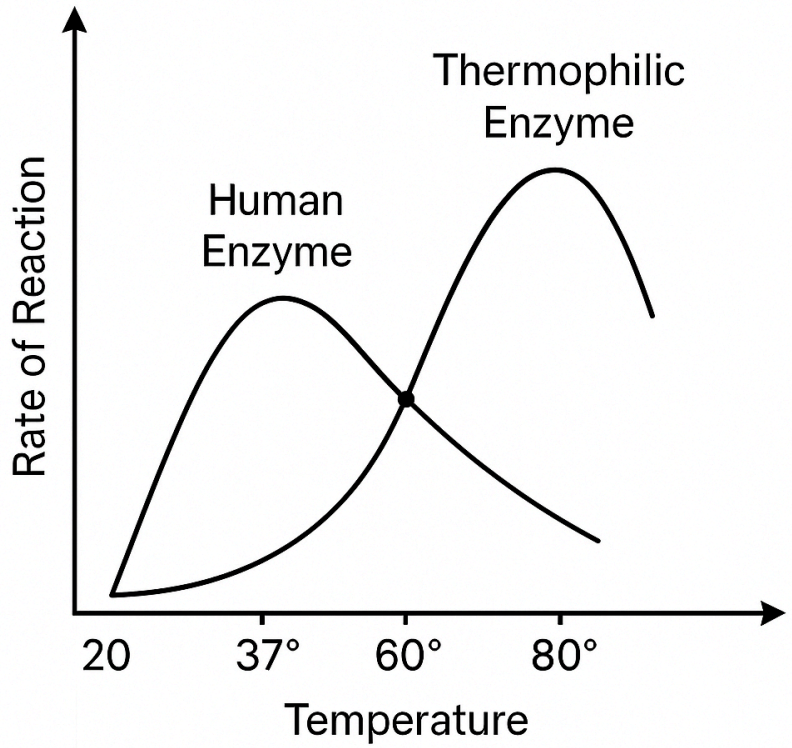
3. Reason for the Difference

The difference in optimum temperature is due to:

- Structural stability of proteins.
- Number of ionic bonds and hydrogen bonds.
- Adaptation to environmental conditions.

Thermophilic enzymes have stronger internal bonding, making them resistant to heat, while human enzymes are adapted to moderate body temperature.

Graph Showing Comparison



Explanation of Graph

- Human enzyme reaches maximum activity at 37°C.
- Thermophilic enzyme reaches maximum activity at much higher temperature (around 70°C).
- Human enzymes denature at high temperatures where thermophilic enzymes remain stable.

✦ **Summary:**

- Optimum temperature = temperature of maximum enzyme activity.
- Human enzymes optimum ≈ 37°C.
- Thermophilic bacterial enzymes optimum ≈ 60–80°C.
- Human enzymes denature at high temperatures.
- Thermophilic enzymes are heat-resistant due to stronger structural stability.

🌟 **Q7: Describe how the concentration of enzyme affects the rate of enzyme action.**

❖ **Answer:**

Enzyme concentration plays an important role in determining the rate of an enzyme-catalyzed reaction. The effect depends on whether the substrate is present in excess or not.

1. When Substrate is in Excess

If a large amount of substrate is available:

- Increasing enzyme concentration increases the number of active sites.
- More enzyme-substrate complexes are formed.
- The reaction rate increases proportionally.

In this case, the rate of reaction is directly proportional to enzyme concentration.

For example, if the amount of catalase enzyme is doubled while hydrogen peroxide is in excess, the reaction rate also approximately doubles.

2. When Substrate is Limited

If substrate concentration is low:

- Increasing enzyme concentration will not increase the reaction rate significantly.
- This is because there are not enough substrate molecules to bind with all enzyme molecules.
- Some enzymes remain unused.

In this case, the reaction rate depends on substrate concentration, not enzyme concentration.

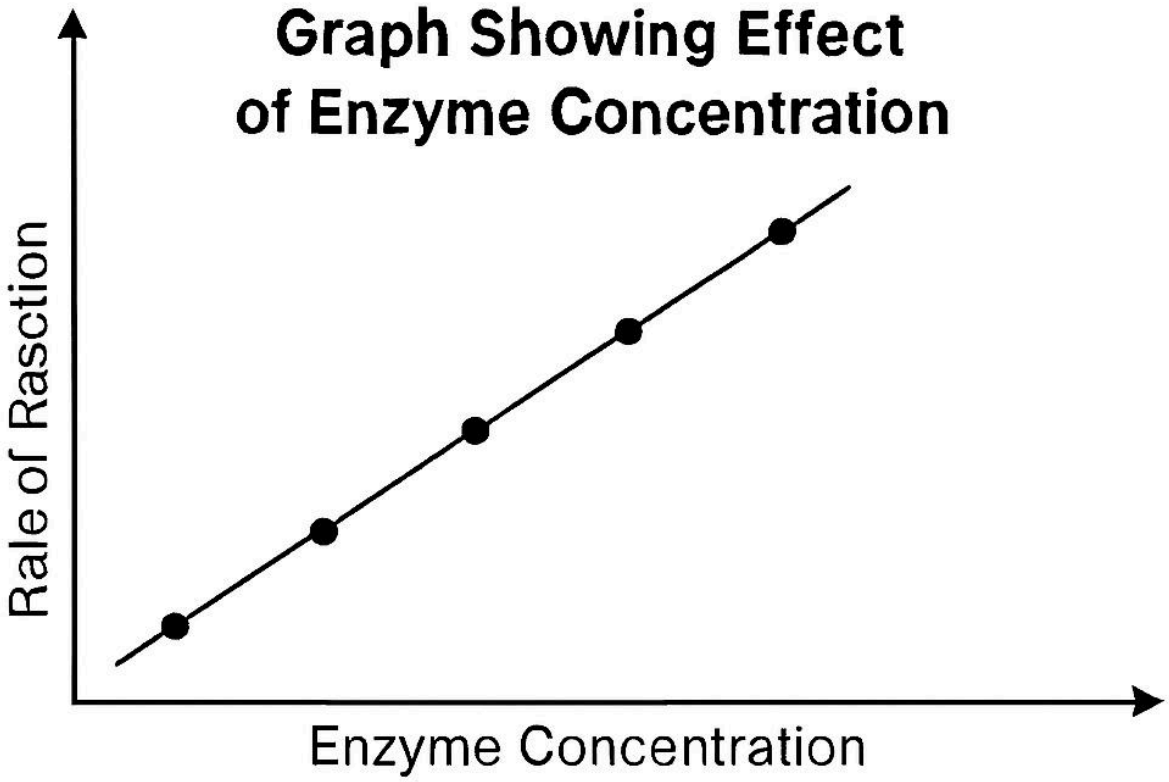
3. Explanation

Enzymes provide active sites for substrate binding. When more enzyme molecules are present:

- More active sites are available.
- More substrate molecules can bind at the same time.
- More products are formed per unit time.

However, the reaction cannot continue increasing indefinitely if substrate becomes limiting.

Graph Showing Effect of Enzyme Concentration



Explanation of Graph

- The graph shows a straight line.
- As enzyme concentration increases, the reaction rate increases proportionally.
- This is true only when substrate is in excess.

Important Point

- Enzyme concentration affects the maximum rate of reaction.
- Doubling enzyme concentration doubles the maximum reaction rate, provided substrate is not limiting.
- Enzyme concentration does not change activation energy; it only increases the number of available active sites.

✦ **Summary:**

- Increasing enzyme concentration increases reaction rate.
- Rate is directly proportional to enzyme concentration (if substrate is excess).
- More enzyme ⟶ more active sites ⟶ more enzyme-substrate complexes.
- If substrate is limited, increasing enzyme concentration has little effect.

🌟 **Q8: Explain the effect of substrate concentration on the rate of enzyme action.**

❖ **Answer:**

Substrate concentration has a direct effect on the rate of an enzyme-controlled reaction. The relationship between substrate concentration and reaction rate can be explained in three stages.

1. At Low Substrate Concentration

When substrate concentration is low:

- Only a few substrate molecules are available.
- Few enzyme-substrate complexes are formed.
- Many active sites remain empty.
- The reaction rate is slow.

As substrate concentration increases:

- More substrate molecules collide with enzyme molecules.
- More enzyme-substrate complexes are formed.

- The reaction rate increases rapidly.
- In this stage, the rate of reaction is directly proportional to substrate concentration.

2. At Moderate Substrate Concentration

As substrate concentration continues to increase:

- Most of the active sites become occupied.
- The reaction rate still increases, but more slowly.
- Fewer free active sites are available.
- The increase in reaction rate becomes gradual.

3. At High Substrate Concentration (Saturation Point)

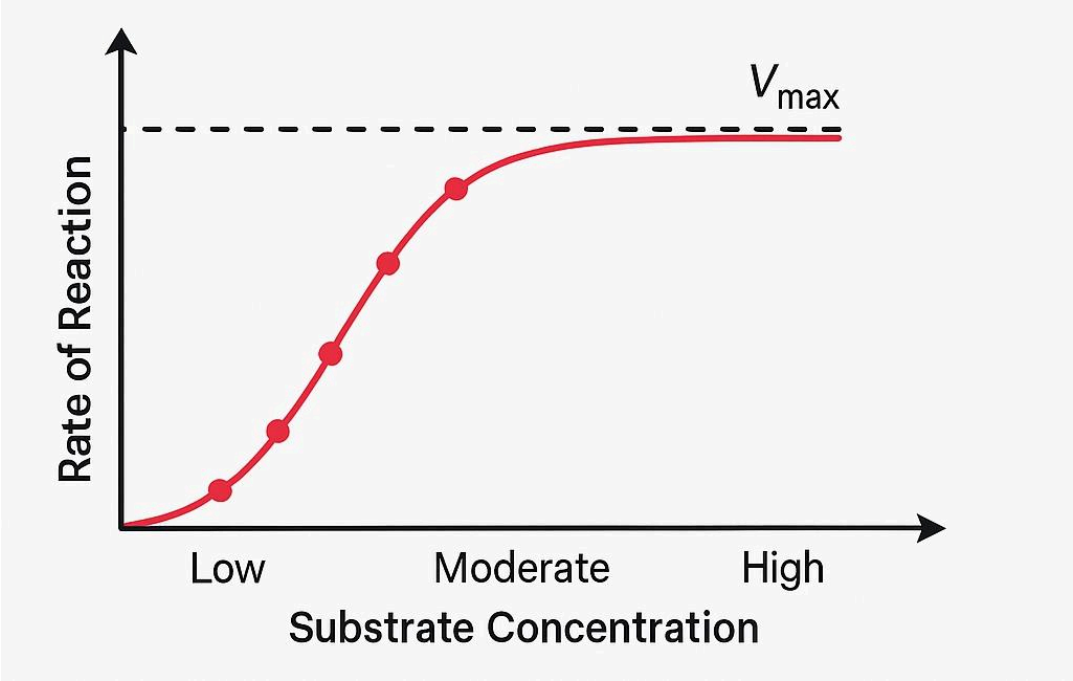
At very high substrate concentration:

- All active sites of enzymes are occupied.
- The enzyme becomes saturated with substrate.
- Maximum enzyme-substrate complexes are formed.
- The reaction reaches its maximum rate (Vmax).

After this point:

- Further increase in substrate concentration does not increase the reaction rate.
- The rate becomes constant.

Graph Showing Effect of Substrate Concentration



Explanation of Graph

- **Initially**, the graph rises steeply (rate increases rapidly).
- Then it rises more slowly.
- **Finally**, it becomes flat at Vmax (maximum rate).
- This plateau occurs because all enzyme active sites are occupied.

Example

During the breakdown of hydrogen peroxide by the enzyme catalase:

- At low hydrogen peroxide concentration, the reaction is slow.
- As concentration increases, the reaction becomes faster.
- At high concentration, the reaction rate becomes constant because catalase molecules are fully saturated.

✦ **Summary:**

Increasing substrate concentration increases the rate of enzyme action up to a certain point. Once all active sites are occupied, the enzyme becomes saturated, and the reaction reaches its maximum rate. Beyond this point, increasing substrate concentration has no further effect.

🌟 **Q9: Describe enzymatic inhibition, its types and its significance.**

❖ **Answer:**

Enzymatic Inhibition

Enzymatic inhibition is the process by which the activity of an enzyme is reduced or stopped by a substance called an inhibitor.

An inhibitor is a molecule that decreases the rate of an enzyme-catalyzed reaction by interfering with substrate binding or enzyme function.

Enzyme inhibition is important in regulating metabolic pathways and is widely used in medicine and industry.

Types of Enzymatic Inhibition

Enzyme inhibition is mainly divided into two major types:

1. Competitive Inhibition
2. Non-competitive Inhibition

1. Competitive Inhibition

In competitive inhibition:

- The inhibitor resembles the substrate in structure.
- It competes with the substrate for binding to the active site.
- The inhibitor binds to the active site of the enzyme.
- If inhibitor binds, the substrate cannot bind.

However:

- This type of inhibition can be overcome by increasing substrate concentration.
- At very high substrate concentration, the substrate outcompetes the inhibitor.

Example:

- Sulfonamide drugs compete with PABA in bacterial cells and prevent the synthesis of folic acid.

2. Non-competitive Inhibition

In non-competitive inhibition:

- The inhibitor does not resemble the substrate.
- It binds to a site other than the active site (called the allosteric site).
- Binding of inhibitor changes the shape of the enzyme.
- The active site becomes distorted.
- The substrate may bind, but the reaction does not occur properly.

Important point:

- Increasing substrate concentration does not overcome this type of inhibition.

Example:

Cyanide binds to cytochrome oxidase and blocks cellular respiration.

Difference in Effect on Reaction Rate

- **Competitive inhibition** increases the apparent Km (affinity decreases) but does not change Vmax.
- **Non-competitive inhibition** decreases Vmax but does not change Km significantly.

Significance of Enzymatic Inhibition

Enzymatic inhibition plays an important role in:

1. Regulation of Metabolic Pathways

Cells control biochemical pathways using inhibition mechanisms such as feedback inhibition.

Example: Isoleucine inhibits the first enzyme in its own synthesis pathway.

2. Drug Action

Many medicines work as enzyme inhibitors.

- Antibiotics inhibit bacterial enzymes.
- Cancer drugs inhibit enzymes involved in cell division.

3. Poisoning and Toxic Effects

Some poisons act as enzyme inhibitors.

Example: Cyanide inhibits respiratory enzymes, stopping ATP production.

4. Industrial and Research Applications

Enzyme inhibitors are used in laboratories to study enzyme mechanisms.

✦ **Summary:**

Enzymatic inhibition is the decrease in enzyme activity caused by inhibitors. It occurs mainly in two forms: competitive and non-competitive inhibition. This process is essential for regulating metabolism and is widely used in medicine and research.

🌟 **Q10: Categorize inhibitors into competitive and non-competitive inhibitors.**

❖ **Answer:**

Enzyme inhibitors are substances that decrease or stop the activity of enzymes. Based on how they interact with the enzyme, inhibitors are mainly categorized into:

1. Competitive inhibitors
2. Non-competitive inhibitors

1. Competitive Inhibitors

Competitive inhibitors are substances that compete with the substrate for binding to the active site of the enzyme.

Characteristics:

- Their structure resembles the substrate.
- They bind directly to the active site.
- They prevent substrate binding.
- Their effect can be overcome by increasing substrate concentration.
- They do not permanently damage the enzyme.

Mechanism:

When the inhibitor binds to the active site, the substrate cannot bind. If substrate concentration is increased, it can outcompete the inhibitor and restore enzyme activity.

Example:

Sulfonamides compete with PABA in bacterial enzymes and block folic acid synthesis.

2. Non-competitive Inhibitors

Non-competitive inhibitors are substances that bind to the enzyme at a site other than the active site.

Characteristics:

- They do not resemble the substrate.
- They bind at a different location called the allosteric site.
- They change the shape of the enzyme.
- The active site becomes distorted.
- Increasing substrate concentration does not overcome inhibition.

Mechanism:

When the inhibitor binds, it alters the enzyme's shape. Even if the substrate binds, the reaction cannot proceed efficiently.

Example:

Cyanide binds to cytochrome oxidase and blocks cellular respiration.

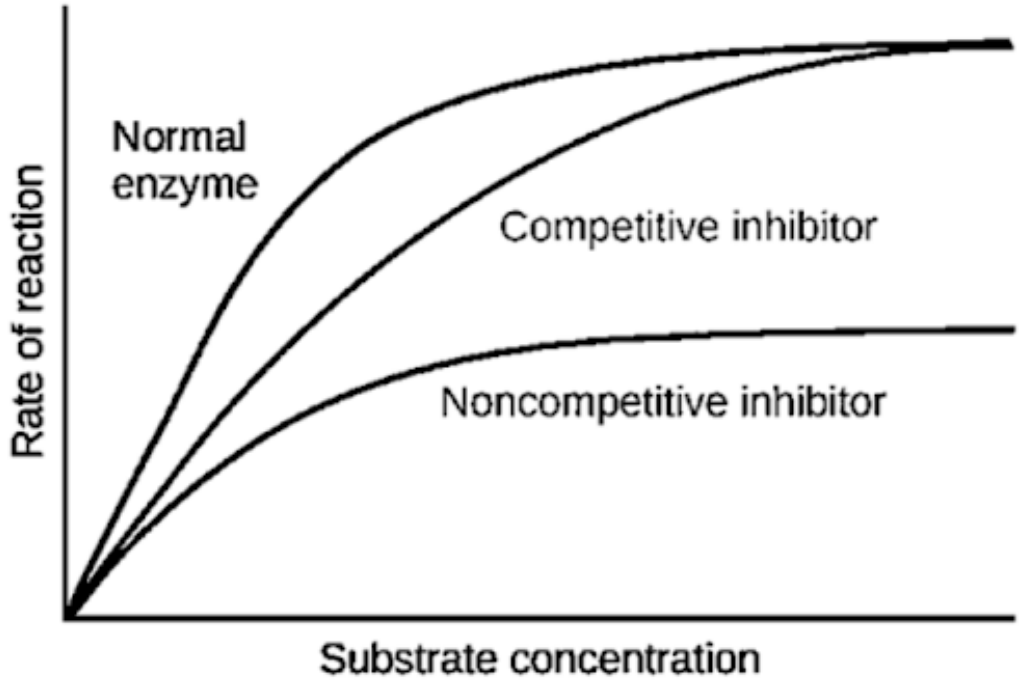
Key Differences in Explanation Form

Competitive inhibitors bind to the active site and compete with the substrate, while non-competitive inhibitors bind to another site and change the enzyme's shape.

Competitive inhibition can be reversed by increasing substrate concentration, but non-competitive inhibition cannot be reversed by adding more substrate.

Competitive inhibition does not change maximum reaction rate if substrate is high, whereas non-competitive inhibition reduces the maximum reaction rate.

Diagram:



✦ **Summary:**

Inhibitors are categorized into competitive and non-competitive types based on their binding site and mechanism of action. Competitive inhibitors compete with the substrate at the active site, while non-competitive inhibitors bind elsewhere and alter enzyme structure. Both types are important in regulating metabolism and in medical applications.

🌟 **Q11: Explain feedback inhibition.**

❖ **Answer:**

Feedback inhibition is a regulatory mechanism in which the final product of a metabolic pathway inhibits an enzyme that acts earlier in the same pathway.

It is also called **end-product inhibition.**

This mechanism prevents the overproduction of the final product and helps maintain balance inside the cell.

How Feedback Inhibition Works

In a metabolic pathway:

- A substrate is converted into a product through a series of enzyme-controlled steps.
- Each step is controlled by a specific enzyme.
- When enough final product is formed, it binds to the first enzyme in the pathway.
- This binding reduces or stops the activity of that enzyme.
- As a result, the whole pathway slows down or stops.

When the concentration of the final product decreases, the inhibition is removed, and the pathway starts again.

Mechanism of Feedback Inhibition

- The final product usually binds to an allosteric site (not the active site).
- This changes the shape of the enzyme.
- The active site becomes less effective.
- The reaction rate decreases.

Thus, feedback inhibition is usually a form of non-competitive inhibition.

Example of Feedback Inhibition

A well-known example is the synthesis of isoleucine from threonine.

- Threonine is converted into isoleucine through several steps.
- The first step is controlled by a specific enzyme.

- When isoleucine accumulates in excess, it binds to the first enzyme.
- This stops further production of isoleucine.

This prevents wastage of energy and raw materials.

Importance of Feedback Inhibition

1. Maintains internal balance (homeostasis).
2. Prevents unnecessary production of substances.
3. Saves cellular energy and resources.
4. Controls metabolic pathways efficiently.

✦ **Summary:**

Feedback inhibition is an important control mechanism in which the final product of a metabolic pathway inhibits the first enzyme of that pathway. It prevents excess production and helps regulate cellular metabolism.

🌟 **Q12: Classify enzymes on the basis of the reactions catalyzed**

❖ **Answer:**

Enzymes can be classified according to the type of chemical reaction they catalyze. There are six main classes:

1. Oxidoreductases

These enzymes catalyze oxidation-reduction reactions, where electrons or hydrogen atoms are transferred from one molecule (donor) to another (acceptor). They are important in energy production and metabolism.

Example: Lactate dehydrogenase, which converts lactate into pyruvate, and cytochrome oxidase in the electron transport chain.

2. Transferases

Transferases catalyze the transfer of functional groups, such as phosphate, methyl, or amino groups, from one molecule to another.

Example: Hexokinase transfers a phosphate group from ATP to glucose, and transaminases transfer amino groups during amino acid metabolism.

3. Hydrolases

Hydrolases catalyze hydrolysis reactions, which break chemical bonds using water. They are very important in digestion and metabolism.

Example: Amylase breaks down starch into maltose, lipase splits lipids into fatty acids and glycerol, and proteases break down proteins into amino acids.

4. Lyases

Lyases catalyze the breaking of chemical bonds without using water, often forming double bonds or rings.

Example: Decarboxylase removes CO_2 from amino acids or organic acids, and aldolase splits fructose-1,6-bisphosphate into two 3-carbon molecules in glycolysis.

5. Isomerases

Isomerases catalyze the rearrangement of atoms within a molecule, forming isomers. They help in converting one molecule into another with the same molecular formula.

Example: Phosphoglucose isomerase converts glucose-6-phosphate into fructose-6-phosphate during glycolysis.

6. Ligases (Synthetases)

Ligases catalyze the joining of two molecules, usually requiring energy from ATP. They are essential in DNA replication and other biosynthetic pathways.

Example: DNA ligase joins Okazaki fragments during DNA replication, and acetyl-CoA synthetase forms acetyl-CoA from acetate.

✦ **Summary:**

In summary, enzymes are classified into six major groups based on the type of reaction they catalyze: oxidoreductases, transferases, hydrolases, lyases, isomerases, and ligases. Each group has specific functions in metabolism and examples that help illustrate their roles in biological systems.

🌟 **Q13: Give examples of enzymes' naming according to substrates**

❖ **Answer:**

Enzymes are often named based on the substrate they act upon. The usual convention is to add the suffix "-ase" to the name of the substrate. This helps identify which molecule the enzyme works on.

Here are some important examples:

1. Amylase

- **Substrate:** Starch
- **Function:** Breaks starch into simpler sugars such as maltose and glucose.
- **Example:** Salivary amylase in the mouth initiates starch digestion.

2. Lipase

- **Substrate:** Lipids (fats)
- **Function:** Breaks down fats into glycerol and fatty acids.
- **Example:** Pancreatic lipase helps digest dietary fats in the small intestine.

3. Protease (Peptidase)

- **Substrate:** Proteins
- **Function:** Breaks down proteins into smaller peptides or amino acids.
- **Example:** Pepsin in the stomach and trypsin in the small intestine.

4. Lactase

- **Substrate:** Lactose (milk sugar)
- **Function:** Breaks lactose into glucose and galactose.
- **Example:** Lactase in the small intestine helps digest milk in humans.

5. Sucrase

- **Substrate:** Sucrose (table sugar)
- **Function:** Breaks sucrose into glucose and fructose.
- **Example:** Sucrase in the intestinal lining aids carbohydrate digestion.

6. Maltase

- **Substrate:** Maltose
- **Function:** Breaks maltose into two glucose molecules.
- **Example:** Maltase in the small intestine completes starch digestion.

7. Cellulase

- **Substrate:** Cellulose
- **Function:** Breaks cellulose into glucose.
- **Example:** Produced by some bacteria and fungi, not naturally in humans.

✦ **Summary:**

Enzymes are commonly named after the substrate they act on, with the suffix “-ase”. Examples include amylase for starch, lipase for fats, protease for proteins, lactase for lactose, and sucrase for sucrose. This naming system helps easily identify an enzyme’s function in metabolism.

INQUISITIVE QUESTIONS

🌟 Q1: Does physical exercise involve anabolic processes, catabolic processes, or both? Give evidence for your answer.

❖ **Answer:**

Physical exercise involves both catabolic and anabolic processes, depending on the type, intensity, and duration of the activity.

Catabolic Processes During Exercise

During exercise, catabolic processes dominate because energy is required for muscle contraction. Large molecules such as glycogen stored in muscles and liver are broken down into glucose, which is further metabolized to release ATP. Fat stores are also broken down into fatty acids and glycerol to provide energy during prolonged exercise. These breakdown reactions release energy, which is immediately used by muscles. Therefore, pathways like glycolysis, beta-oxidation of fats, and cellular respiration are activated, providing the necessary fuel for physical activity.

Anabolic Processes After Exercise

Anabolic processes occur primarily after exercise, during recovery. These involve the synthesis of larger molecules from smaller molecules, usually consuming energy. For example, the body repairs damaged muscle fibers by synthesizing new proteins. Energy from ATP and nutrients is used to form glycogen from glucose for storage in muscles and liver. Anabolic hormones such as insulin and growth hormone help in muscle growth and recovery, ensuring the body restores its energy stores and structural components.

✦ **Summary:**

- Catabolic processes break down molecules like glycogen and fats to release energy during exercise.
- Anabolic processes rebuild tissues and restore energy stores after exercise.
- Both processes are essential for proper muscle function, energy supply, and recovery.

🌟 **Q2: If a chemical reaction could occur without an enzyme, why is it important to have one?**

❖ **Answer:**

Even though some chemical reactions in the body can occur without enzymes, enzymes are essential for life because they greatly increase the speed and efficiency of reactions, ensuring that biological processes happen fast enough to sustain life.

Role of Enzymes in Chemical Reactions

- All chemical reactions require a certain amount of energy to get started, called activation energy.
- Without an enzyme, a reaction may still occur, but it will be extremely slow because molecules collide randomly and must have enough energy to react.
- Enzymes lower the activation energy, making it easier for reactions to occur.
- This allows reactions to happen quickly at normal body temperature, which is essential for metabolism and survival.

Importance of Enzymes

1. Speed Up Reactions:

- Reactions in cells need to occur in milliseconds or seconds to support life.
- **For example,** the breakdown of hydrogen peroxide by catalase happens almost instantly with the enzyme but would take years without it.

2. Control and Regulation:

- Enzymes allow cells to control when and where reactions occur.
- They help regulate metabolic pathways efficiently.

3. Specificity:

- Enzymes are highly specific for their substrates, ensuring that only the correct reaction occurs.
- This prevents unwanted side reactions and ensures proper metabolism.

✦ **Summary:**

- Reactions without enzymes are very slow.
- Enzymes lower activation energy and speed up reactions.
- Enzymes ensure specificity, control, and regulation of reactions.
- Essential for life, even if the reaction can technically occur without them.

🌟 **Q3: Construct and interpret graphs based on data about the effect of temperature, enzyme concentration, and substrate concentration on the rate of enzyme action.**

❖ **Answer:**

The rate of enzyme action is affected by several factors, including temperature, enzyme concentration, and substrate concentration. Graphs are used to show how these factors influence the reaction rate.

1. Effect of Temperature

Explanation:

- As temperature increases, the kinetic energy of molecules increases. This leads to more frequent collisions between enzyme and substrate, increasing the reaction rate.
- The reaction rate reaches a maximum at the optimum temperature, where the enzyme is most active.
- Beyond the optimum temperature, the enzyme denatures, losing its shape, and the reaction rate drops sharply.

Graph Description:

- The graph has temperature on the x-axis and reaction rate on the y-axis.
- It forms a bell-shaped curve: rising with temperature, reaching a peak at the optimum, and then falling at high temperatures.

2. Effect of Enzyme Concentration

Explanation:

- Increasing enzyme concentration increases the number of active sites available for substrate molecules.
- When substrate is in excess, the reaction rate increases proportionally to enzyme concentration.
- If substrate is limited, increasing enzyme concentration has little or no effect on the rate.

Graph Description:

- The graph has enzyme concentration on the x-axis and reaction rate on the y-axis.
- It shows a directly proportional increase when substrate is abundant, forming a straight rising line.
- If substrate is limited, the graph plateaus, showing no further increase in reaction rate.

3. Effect of Substrate Concentration

Explanation:

- At low substrate concentrations, the reaction rate is slow because there are fewer molecules to bind to the enzyme.
- As substrate concentration increases, the reaction rate increases because more enzyme-substrate complexes form.
- At high substrate concentration, all enzyme active sites are occupied (saturation point), and the reaction reaches maximum velocity (Vmax).

Graph Description:

- The graph has substrate concentration on the x-axis and reaction rate on the y-axis.
- It shows a rapid rise at low concentrations, then a gradual increase, and finally a plateau at Vmax.

Interpretation of Graphs

- **Temperature Graph:** Shows the optimum temperature for enzyme activity and indicates denaturation at high temperatures.
- **Enzyme Concentration Graph:** Shows how reaction rate depends on the availability of active sites and substrate.
- **Substrate Concentration Graph:** Demonstrates enzyme saturation and the concept of Vmax.

Overall: These graphs help students understand how enzymes function under different conditions and are critical for interpreting experimental data in biology.

✦ **Summary:**

- **Temperature:** Reaction rate increases to optimum, then falls due to denaturation.
- **Enzyme Concentration:** Rate increases with enzyme, plateaus if substrate is limiting.
- **Substrate Concentration:** Rate increases with substrate, plateaus at saturation (Vmax).
- Graphs help visualize enzyme kinetics and interpret experimental data.

🌟 Q4: Identify the competitive and non-competitive inhibitors from a list of chemicals used in daily life.

❖ **Answer:**

Enzyme inhibitors are substances that reduce or stop the activity of enzymes. They are classified into competitive and non-competitive inhibitors based on how they interact with the enzyme. Many chemicals we use in daily life act as enzyme inhibitors.

1. Competitive Inhibitors

Definition: Competitive inhibitors are chemicals that resemble the substrate and compete for the active site of the enzyme.

Mechanism: They temporarily block the substrate from binding to the enzyme. Increasing substrate concentration can overcome their effect.

Examples from Daily Life:

- **Methotrexate:** A drug that competes with folic acid in cancer treatment.
- **Sulfonamide antibiotics:** Compete with PABA (para-aminobenzoic acid) in bacteria to stop folic acid synthesis.
- **Malonate:** Competes with succinate in the Krebs cycle (used in lab experiments).

Note: Foods or chemicals that structurally resemble substrates can also act as competitive inhibitors.

2. Non-Competitive Inhibitors

Definition: Non-competitive inhibitors bind to a site other than the active site (allosteric site) and change the shape of the enzyme, preventing the reaction even if substrate is present.

Mechanism: Their effect cannot be overcome by increasing substrate concentration.

Examples from Daily Life:

- **Cyanide:** Binds to enzymes in the respiratory chain and stops ATP production.
- **Heavy metals like mercury or lead:** Bind to enzymes and denature them.
- **Fungicides or pesticides:** Can bind to enzyme sites in pests, stopping metabolism.

How to Identify from a List

1. Check if the chemical resembles the substrate ⟶ Competitive inhibitor.
2. Check if the chemical binds elsewhere and changes enzyme shape ⟶ Non-competitive inhibitor.
3. Consider whether increasing substrate would overcome inhibition:
    - If yes ⟶ Competitive
    - If no ⟶ Non-competitive

✦ **Summary:**

- **Competitive inhibitors:** Resemble substrate, bind to active site, overcome by more substrate. Examples: Methotrexate, sulfonamides.
- **Non-competitive inhibitors:** Bind to other sites, change enzyme shape, not overcome by substrate. Examples: Cyanide, heavy metals, some pesticides.

- **Identification:** Substrate resemblance and ability to overcome inhibition help classify inhibitors.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

Author: Muhammad Asghar

Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.